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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

AERIAL ENGINEERING[1]

THE attention of the section was directed to aeronautics as long ago as 1886, when my distinguished predecessor, Octave Chanute, in his address at Buffalo, mentioned the possibilities of aerial navigation, a subject which entirely absorbed his later years and which he lived to see completely realized. Again in 1904, Professor C. M. Woodward devoted a portion of his vice-presidential address at Philadelphia to a consideration of the navigation of the air, which at that time had been accomplished with dirigible balloons. Papers on aeronautical subjects, or relating thereto, have been presented in increasing numbers to the section, reaching a maximum of eleven in 1909. Last year, the writer, as chairman of the section, made a special effort to secure such papers through a preliminary circular, thus worded:

> The rapid advance in the navigation of the air during the past year has attracted serious attention to scientific aeronautics. The construction of dirigible balloons and flying machines is essentially a mechanical problem and as such merits consideration by this section, especially since no engineering society has yet taken this action. Accordingly papers are invited relating to aerodynamics and other branches of aeronautics and also discussing possible courses of instruction in colleges and technical schools.

As a result ten papers were presented and an aeronautical curriculum was for the first time discussed here.

The subject of this address, "Aerial

[1] Address of the vice-president and chairman of Section D—Mechanical Science and Engineering. Washington, 1911.

Engineering," suggests a new field for the profession, analogous to marine engineering and which may in the future prove almost as important. So long as the spherical balloon was the sole method of rising in the air, the technical questions involved belonged to physics and chemistry rather than to engineering, but with the advent of the dirigible balloon and the aeroplane, the mechanical engineer was called upon to provide the lightest possible motive-power and to design the framework of the balloon and the supporting surface of the aeroplane to sustain the greatest stresses with the least weight.

The determination of the meteorological conditions at different heights and places and under all weather conditions belongs to the meteorologist and his observations originally made in the interest of pure science now become of practical value. The necessity of knowing the conditions which may be encountered by air-craft in their voyages through space of three dimensions will ultimately lead to the construction of flying charts at different levels but otherwise similar to the sailing charts for the ocean. A beginning has already been made by the writer, who has published a series of twenty-four charts based on material collected by the Blue Hill Observatory in the United States and over the Atlantic Ocean. Since in the air as on the earth it is not the average, but the individual thing, which happens, an attempt is made to specialize for the time of day and season and also to show the sequence of wind-changes aloft which accompany different barometric conditions at the ground. A knowledge of the wind, which varies with both place and level and depends upon the meteorological situation, has a far greater importance for the airman than for the navigator, whose vessel rests on a dense and relatively stationary medium. In general, the velocity of the wind increases with height and its direction becomes more constant, but the observations at Blue Hill seem to indicate that the gusts of wind, while increasing with the average velocity, decrease as we rise in the free air and are greatest near the ground in northwest winds, where they may be double the average speed. In experiments there by Mr. S. P. Fergusson, as many as ten pulsations per second were recorded by the most sensitive anemometers on a wide time-sheet. The uprush of air under cumulus clouds, which are especially strong when they become cumulo-nimbus or thunder-clouds, are dangerous to all air-craft that depend on dynamic equilibrium, as are the eddies termed by aviators "holes in the air," which are produced by superposed currents having different velocities or directions. It is possible for an aeroplane to fall when traveling with the wind if the gust greatly outstrips the mean velocity of the current that carries the aeroplane, which our experiments show to be a frequent occurrence, because its relative motion through the air, due to its motor, and therefore the upward component which furnishes support, is decreased by the inertia of the flying-machine preventing it from responding to the sudden impulse. The same thing may happen when going against the wind if a sudden lull occur, and if the aeroplane pass abruptly up or down into another air stratum of different velocity. Such local currents and atmospheric eddies, which have long been known to meteorologists from the behavior of their kites and balloons, will now be studied *in situ* and with danger by the aviator. Some of these disturbances may be counteracted by automatic control of equilibrium, but generally by increasing the speed and size of the machine and so rendering it less susceptible to the influence of those per-

turbations of the atmosphere which are of limited extent and duration. To-day the most needed improvements in aeroplanes are stability in wind-eddies and safety in landing.

The meteorological phenomena causing these difficulties are discussed here at some length because their solution belongs to mechanical science and therefore merits the attention of our best engineers. There is an erroneous idea that the aeroplane has been developed without laboratory experiments and that a study of the theory of flight, and hence the science of aviation, does not require theoretical knowledge of the different factors which influence it. The pioneers in aviation, Lilienthal, Maxim, Langley and the Wrights, experimented in the laboratory with surfaces exposed in wind-tunnels and on whirling-tables, and the best shapes for balloon-envelopes to present the minimum resistance to propulsion were also obtained from models. Theoretical knowledge based on experiments is indispensable to the aeronautical engineer as distinguished from the aviator. Only on such a foundation can we build up the new science of aeronautics and a technology which is indispensable for the development of this new branch of engineering.

M. Eiffel, the distinguished engineer, in describing the results of his recent work in aerodynamics says:

> It must be admitted that the experiments in the laboratory with small models can furnish data useful to aeronautical constructors, saving them both money and time in experimenting. For a series of laboratory experiments made on model aeroplanes, or on wings of small size, which can be quickly and surely modified, gives the basis for later computation, either for the section of the different members depending on the strength of the material used, or for the conditions of equilibrium and stability, having regard to the calculated or assumed weight for each member. The same thing applies to a model of a screw-propeller which tried under proper conditions may give information about the action of the actual propeller. The experiments with full-sized aeroplanes are almost always disturbed by wind, which introduces very large causes of error, and the trials being made necessarily with new apparatus of uncertain operation are generally dangerous. On the other hand, laboratory experiments can be conducted at any time and under different conditions and their results enable the knowledge of the engineer to replace the inspiration of the constructor, which in new fields may sometimes lead to fortunate discoveries, but may also give rise to costly mistakes.

The establishment of aerodynamical laboratories, therefore, marks the entrance of aeronautics into the domain of engineering. Probably the first of these was organized by Captain, later Colonel, Charles Renard at the Central Establishment for Military Aeronautics at Chalais-Meudon, near Paris, about 1884. Here important investigations on light motors and the resistance of bodies of different shapes to motion through the air were conducted, which resulted in the first successful dirigible balloon, *La France*. Experiments upon lifting screw-propellers, with a view to aviation, followed, and Colonel Renard carried on similar work until 1903, when he was succeeded by other officers and the name of the laboratory changed.

Important experiments on the resistance of the air to falling bodies were made between 1903 and 1906 by the eminent constructor of the Eiffel Tower there and later at his laboratory provided with a large wind-chamber on the Champs de Mars. Of great importance are the determination of the relations between the velocity and pressure of the air on a normal plane and upon plane and other surfaces at varying angles of incidence, the distribution of the pressure over the surface and the tests of aeroplane-wings. The results of the experiments have been published in two large volumes with the detail and elegance characteristic of M. Eiffel.

Another experimental establishment of wider scope has recently been created in France through the generosity of a patron of aeronautics, M. Deutsch de la Meurthe. This is the Aerotechnical Institute of the University of Paris, located at Saint Cyr, near the Buc aerodrome and the Satory camp, the center of military aeronautics in France. It is planned to study all theoretical and practical problems of aviation and aerostation relative to the support of bodies in the air, both at rest and in motion. The institute is primarily a testing establishment where constructors and experimenters may bring aeroplanes, or their parts, to be tested by the best devices at actual cost; and secondarily it is an institution where aerodynamics is studied in theory and in practise by experts for the government and some of the results are published as an aid to the science. The invested capital is $100,000 and an additional annual income of $3,000 is provided by M. Deutsch. The director of the institute is Professor Maurain, who has an advisory committee composed of eminent French scientific and aeronautical experts, including representatives of the University of Paris and the Aero-Club of France and government officials.

An earlier laboratory of the same nature in Russia was the Aerodynamic Institute of Koutchino, founded in 1904 by M. Riaboutchinski in connection with the University of Moscow. Its object is to investigate problems of pure and applied aerodynamics, general aeronautics and meteorology and three volumes containing results of the valuable investigations have been published. The initial cost of the plant was about $77,000 and the proprietor further donates some $27,000 a year for the researches.

An aerodynamical laboratory was established at Göttingen, Germany, in 1908, through the initiative of the Society for the Study of Motor Air-ships, aided by the Göttingen Technical Association, the government and the Krupp gun-firm, the laboratory receiving in the aggregate more than $7,000 a year. Professor Prandtl, who also holds the chair of aeronautics in the University of Göttingen, is director of the laboratory, and has as advisers Germans prominent in physics and engineering. In Austria there are at least two private experimental laboratories.

The National Physical Laboratory at Bushy Park, near London, now has an aerodynamical department with an advisory board composed of men eminent in different branches of science, Lord Rayleigh being the chairman, who are appointed by the prime minister. The experimental apparatus for investigating general questions in aerodynamics includes a wind-tunnel, a whirling-table, two wind-towers for experiments in the natural wind, a motor-plant and arrangements for testing the permeability of balloon and aeroplane fabrics and the strength of light alloys for construction. A report of the advisory committee for 1909–10 has been published as a government blue book.

There is a well-equipped laboratory in Italy for the military aeronauts and in other European countries similar establishments exist, the work of which is not disclosed.

From this rapid survey of the principal scientific establishments for the study of aeronautics in Europe, it will be seen that they may be divided into two classes: first, those privately endowed laboratories, which are either personal or connected with some institution but whose object is the advancement of the science and practise of aeronautics; and second, those supported by the government for military

purposes, but which may publish data of value to constructors and students.

Instruction in aeronautics is now given in many foreign technical schools and universities, the best known course of study being under Professor Prandtl at the University of Göttingen, in connection with the laboratory already mentioned. M. Basil Zaharon, a wealthy Greek residing in Paris, has endowed a chair of aeronautics at the Sorbonne with a fund of $140,000, so that France will soon rival Germany in facilities for training students in this science.

The United States is almost absolutely lacking to-day in aeronautical laboratories and technical instruction, for the brilliant researches in the past of Langley, Zahm and Nipher have not been followed by similar work since the flying machine was realized. Our government maintains no aerodynamic laboratory and few of our technical schools or colleges possess apparatus for this purpose, while none offer regular instruction though some investigations have been made by advanced students. The instruction in flying by the so-called aviation schools is, of course, unworthy of consideration, since the best of these only teach the aviator to operate and repair his machine as the automobile school does the chauffeur.

It appears likely that the demand for collegiate instruction from young men wishing to enter aerial engineering as a profession will soon require the establishment of regular courses of study based on the European curriculum, at the completion of which a degree or certificate of proficiency shall be given, ranking with that conferred in other professional courses. It seems to the writer that aerial engineering can best be taught in institutions that now possess departments of mechanical engineering and naval architecture, for the preliminary training would be the same as that now given in these studies and the specialization would consist in the substitution of air for water as the navigable medium. The installation of laboratories having powerful blowers connected with large wind-tunnels, or equipped with whirling-tables in a large enclosed space, is, of course, essential.

The board of governors of the Aero Club of America have requested the committee on aerodynamics to consider the most feasible method of organizing and maintaining an aeronautical laboratory in this country. This committee, of which the writer is a member, through its chairman, Dr. A. F. Zahm, has made a preliminary report containing the following suggestions. The fact that the United States Signal Corps and the Bureau of Navigation of the Navy Department will probably establish such laboratories for their officers, should not prevent the creation of a civil aeronautical institution similar to those already described in England, Germany and Russia. If the English precedent is followed, and the laboratory be maintained by the government, it could properly be attached to the Bureau of Standards, but if privately endowed, like those on the continent of Europe, it might become an adjunct of the Smithsonian Institution, and this would be the more appropriate because the institution through its late secretary has already undertaken extensive aerodynamical researches and still possesses workshops and a special library.

Two years ago our chairman, Professor G. F. Swain, in speaking of engineering as a profession, remarked that aeronautics was a peculiarly appropriate field for this section to occupy, because it had not been taken up to a considerable extent by the engineering societies. This is still true today and the object of this address is to

convince the members of this section and of our engineering societies of the importance of establishing aeronautical laboratories and courses of instruction in aerial engineering in America, in order to keep pace with their rapid development in Europe. The fundamental researches of our late associates, Langley, the physicist, and Chanute, the engineer, which first demonstrated the principles of dynamic flight, should be an incentive to further scientific work in this country towards its perfection.

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THE INDEPENDENCE OF THE CULTURE OF THE AMERICAN INDIAN[1]

If one considers for a moment a map of the world, the two American continents are seen to possess one obvious characteristic in which the other great land masses do not share—isolation. From the time of the discovery America has been known as the new world, and indeed the name seems well deserved. Europe, Africa and Asia together with Australia and most of the islands of the Pacific form a closely connected and nearly continuous area. Within its limits races have come and gone, civilizations and cultures have risen and passed away, but each has been to some extent directly or indirectly influenced by others, and strong cultures have made their effects felt, albeit but faintly sometimes, to the furthest limits of this old world. A Mongol chieftain once made all Europe tremble; the conquests of a Chinese king perhaps decreed the age-long wanderings of the Polynesians; and the visions of an Arabian epileptic were the cause of movements that have overthrown empires and profoundly influenced the life of men from the northern rim of Europe to the edge of the South African deserts, and from the Pillars of Hercules to the Spice Islands of the east.

To understand and analyze, therefore, the culture of any given people or portion of the old world, the possible far-reaching effects of other cultures even although remote, must be borne in mind. In this it would seem, however, that America might be excepted. As far back at least as history or tradition goes it has stood alone, touching that other and older world only in the frozen north, and when, at the time of the discovery, Spanish, French and English broke down its barriers of isolation, it was to reveal peoples and cultures which for centuries and perhaps millenniums had been developing their own civilizations apparently untouched, neither influencing nor being influenced by those of the old world.

Yet in spite of the apparent isolation in which the people of America lived, no sooner were they known than various general similarities between them and peoples of the old world were observed, and theory after theory was brought forward attempting to derive them or their culture *en bloc* from elsewhere. Some, mostly of the earlier period, looked to the Semites and the Lost Ten Tribes, others to China and a party of Buddhist monks; others still to the islands of the South Seas or to Egypt and the fabled Atlantis. All such theories, however, it need hardly be said, belong to the period before the present in which more accurate and abundant observation and careful scientific method are employed. In spite of the many such theories exploited, the majority of students refused to accept the conclusions, many indeed going to the opposite extreme. They admitted that the various cultures which, as a result of the activity of investigators, had been

[1] Address of the vice-president and chairman of Section H, Washington, 1911.